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LIFE HISTORY NOTES ON THE WASP, *POLISTES ANNULARIS*.

BY PHIL RAU,

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The fact that the petiole of the nest of *P. annularis* is thickened from time to time as the weight of the nest increases shows that the wasps can adapt their behavior to the needs of the day, even though their chain of work is interrupted. The first part of the nest to be made is the petiole; this is made by the queen long before the first workers emerge. Fig. 1 shows a queen-made nest, and special attention is called to the petiole made by this species at one side of the nest. This habit is constant in all nests. As the nest grows this is greatly thickened by the workers, even though instinctively they should only gather food and make cells. How do they know that the weight increases or that the nest needs further support? If they wait to be aroused to action by the shaking of the nest in the wind, or its tottering under the increased weight, there is great danger of being too late; hence they must follow some other stimulus.

An *annularis* nest was discovered at Wickes on August 24, 1921, which was near enough to the level of the eye to be clearly observed. It was literally weighted down with wasps; both sides of the nest were covered with them, and a few were on the stem of the shrub. A terrific storm with heavy rain lasting for an hour and a half did not disturb them, for when I returned immediately after the rain I found them in the same number and positions. I could clearly observe their action when I approached them; they displayed their nervousness by slightly tilting the body upward, resting on the four hind legs, while the two front legs were vibrated very rapidly and all in apparent unison. The antennae were held out perfectly rigid. Since the distal portions of both the antennae and the legs are colored a conspicuous orange yellow, the extended antennae and legs appear so similar that one must look sharply to see which is which. It seems at first, when one sees the rigidity of the antennae and the chorus of rapidly vibrating legs, that the organs of sense are in the latter, but it is more likely that the legs, which have warning coloration, have acquired the habit of warning agitation, while the antennae are held rigid in anticipation of any new developments in the impending disturbance or danger. Waving a handkerchief three feet from the nest brought this response, but at a greater distance there was no response. Careful rocking of the shrub, as though by the wind, did not arouse this reaction, but snapping off a twig from the lower branches elicited it at once. With all this they clung to the nest and left it only when unduly provoked.

A little later in the season some other experiments showed interesting contrasts. While the experiments appeared at first to be the same, the results were very different, no doubt because there were essential differences in the conditions. In September we tried shaking several tree-top nests of *P. annularis*. Almost immediately nine-tenths of the occupants (the nests I worked with each had perhaps one hundred to two hundred adults on them) dropped to the foliage or

ground below; a few remained on the nest, but a second shaking usually dislodged most of them. Of all this number, almost none would defend the nest, but usually there was one that would swoop down upon the intruder and administer a sting. The sting is usually more severe than that of *P. pallipes*. With their numbers they could easily have put one to rout, and still the instinct or intelligence varied so that there were only a very few, or sometimes only one, that would readily fight. May it be that it was the oldest on the nest, the queen, who thus manifested a home interest different from that of the others? This behavior in September appears at first inconsistent with that seen only the month before. At the earlier date, there were young in the nest to be defended, while a little later there were none. In the first case also the snapping of a twig or the waving of a challenge obviously announced the approach of an enemy, while the waving of the tree was in such close imitation of the wind that it did not arouse their ire.

In a sister species, *P. pallipes*, a marked difference in moods was shown at different times by identical queens. When resting alone they were coldly indifferent to my approach, but as soon as young were present in the nest, the same individuals suddenly became extremely bellicose.

In the fall of 1921, about one-third of the *P. annularis* nests taken had a heavy, webby net spun across the cells; this unquestionably denoted the work of other insects, but whether the webmaker actually parasitised the larvae of the wasps or only attacked the paper I could not at that date determine. Some of these infested nests taken into the laboratory gave forth both lepidopterous and hymenopterous insects the following April. The moth was identified by Mr. August Busck as *Tinea fuscipunctella* Haworth, and the Hymenoptera were identified by Mr. A. B. Gahan as *Apanteles carpatus* Say and *Tetrastichus* sp. In all probability none of the three species is directly parasitic on *P. annularis*, but the moth, which is nearly related to the clothes moth, feeds upon the papery material of the nests, and the two species of Hymenoptera are probably parasitic upon this moth.

CONCERNING *SCOLOPS COCKERELLI*, (HOMOPTERA,
FULGORIDAE).*

BY PAUL B. LAWSON,

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In his paper on the genus *Scolops* (Kansas University Science Bulletin, Volume XVIII, page 417, 1928), Breakey comes to the conclusion that *Scolops cockerelli* Fowler is a synonym of Ball's *Scolops robustus*. On pages 427-428 he records the comparison of specimens of a number of closely related species with the type specimen of Fowler's species by Mr. W. E. China of the British Museum. As a result of these comparisons Breakey felt that there were no differences between the two species mentioned above that were specific, or that could not be accounted for by the slight variation in size, color, etc., which are known to exist within the species.

After Breakey sent his paper to press the writer while examining a series of *Scolops* specimens from Texas, collected by members of the 1927 Entomological

*—Contribution from the Department of Entomology, University of Kansas.

Survey party of the University of Kansas, ran across a number of specimens which seemed different from any he had ever seen and which seemed quite close to the specimen described and figured by Fowler. A pair of these specimens were sent Mr. China for comparison with the type, who reported that while there were minor differences between these specimens and the type, yet, in the essential features they were alike, the cephalic process was the same in the two males and that, "we can safely identify your specimen as *S. cockerelli*." Mr. China had always reported, in comparison with previous specimens of several species sent him by Mr. Breakey that in his judgment *S. cockerelli* was unlike anything he had received before. His feeling as to the identity of the specimens in this case, coupled with our own judgment that these specimens were probably identical with Fowler's species, makes us reasonably sure that the species is distinct and that it is not a synonym of *S. robustus* Ball.

A comparison of a large series of the two species shows that Ball's species is definitely smaller and the cephalic process is shorter and more slender. Moreover the elytra do not become as deeply colored with dark brown as in the darker specimens of *S. cockerelli*. This opinion is strengthened by Van Duzee's determination of a specimen from Mesilla, New Mexico, which is within forty-five miles of the type locality, as a specimen of this species. This specimen is identical with the specimens before the writer which were taken as follows: Potter County, Texas, R. H. Beamer; Canyon, Texas, L. A. Stephenson; Amarillo, Texas, P. A. Readio; Amarillo, Texas, L. D. Anderson. All these specimens were taken July 7, 1927. Doctor Beamer reports that most of the specimens were taken from the somewhat ranker vegetation in what appear to be small dry lake beds which are scattered over the plains.

The following is the description of the female which Mr. China compared with the type, and which may be designated as the allotype:

A greenish-yellow species with tegmina usually heavily marked with brown. Length from tip of process to tip of tegmina 8 mm. Cephalic process 1.3 mm. long.

Structural Characteristics: Cephalic process about two-thirds as wide at sulcus as vertex, about as long as front, broadest at sulcus, tapering gradually to the rounded apex. Vertex with lateral carinae strongly developed; median carina obsolete. Front widest across basal angles, margins converging gradually till near sulcus, then suddenly constricted; with five carinae, the middle one fading out near sulcus. Clypeus with strong median carina. Pronotum with marginal and submarginal carinae distinct; central disc but little wider than long, the median carina prominent; posterior margin broadly concave. Scutellum about two-thirds as long as wide; central disc with lateral carinae distinct, with median line slightly raised anteriorly and slightly depressed posteriorly. Cubitus and media of tegmina forking near junction of second and third anal veins.

Color: Pale yellow, tinged here and there with greenish, the elytra heavily marked with dark brown in well colored specimens. Vertex yellowish, tinged with brown, shiny, with a pair of small black spots anteriorly. Cephalic process yellowish with a narrow dark line in dorsal groove and two broader dark lines along lateral carinae. Lateral compartments of front spotted with brown, central compartments and clypeus unmarked. A large black spot below postocu-

lar process. Pronotum pale yellow, with four black spots directly caudad of vertex and a pair of very small ones caudolaterad of these. Scutellum darker than pronotum, tinged with green, with four large indefinitely-margined black spots. Tegulae brown. Elytra pale yellow but so heavily marked with brown that the yellow shows only in small spots along the veins and particularly in caudal part of costal cell, in large light spots at forking of both media and cubitus and along first sector of cubitus; elytra appearing much more distinctly mottled than in *S. robustus*. Below yellowish, mottled with brown, fore and hind legs darker and spines of hind legs black.

Taken by Dr. R. H. Beamer, Potter County, Texas, 7/7/27.

Another specimen, designed as the holomorphotype, agrees in color with the above description except for a few extra brown spots on the pronotum and a longer elytra, which extend much beyond the abdomen, give the insect a narrow-darker scutellum which bears two large black spots on its cephalic margin. The er and more elongate appearance. Taken by L. D. Anderson, Amarillo, Texas, July 7, 1927.

In over twenty other specimens of this species taken in the same region, one sees a considerable variation in color. The teneral specimens are decidedly greenish and the others range in color from a brownish-green to a rather dark brown in the darkest specimens.

Types deposited in the Snow Entomological Collection.

NOTES ON PTEROPHORIDAE WITH DESCRIPTION OF A NEW OIDAEMATOPHORUS (LEPIDOPTERA).

BY ANNETTE F. BRAUN,
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***Platyptilia fragilis* Walsingham.**

In an earlier paper (1925, Trans. Am. Ent. Soc., LI, 184) brief reference was made to larvae of *Platyptilia fragilis* in the seed-capsules of *Pentstemon cyananthus*, one of the common perennials of the sagebrush association. The presence of the larvae in the seed-capsules while feeding is not apparent, although a large portion of the seeds contained therein are eaten. The full-grown larva leaves the capsule by a circular hole near the middle of one of the valves, attaching itself by the posterior end to some nearby object. Pupa more or less shaded with red on first five or six abdominal segments.

Larvae were collected July 11, at Logan, Utah. At this time few feeding larvae remained, but perforated pods were very numerous. Imagoes July 27 to August 28, 1924.

***Stenoptilia coloradensis* Fernald.**

A series of specimens of this species, all of the small form, expanding only 18 mm., was reared on *Gentiana quinquefolia*, from Beaver Pond, Adams County, Ohio. The larva attacks the center shoot, the main stem of the

plant, which at the time of feeding of the larvae (July) is almost unbranched. In the process, the stem below the tip is cut, so that the end of the shoot wilts and finally turns black. The larvae lives amongst the wilted leaves, boring down into the stem; at the end of the feeding period it consumes the wilted leaves as well.

Mature larva. Whitish, cylindrical, middorsal line darker, whitish subdorsal and lateral lines above and below spiracles; knobbed glandular hairs arising from the warts; warts i, ii and iii each with a pair of very unequal hairs, wart iv + v with two hairs of nearly equal length.

Pupa. Green or yellowish, often with a faint reddish dorsal patch on metathorax and first abdominal segment. The pupa is usually found on the stem of the food plant, attached head downward and diverging from the stem at an acute angle.

At the time of collection, July 19, 1927, the larvae were nearly all full grown, and pupae were found attached to the stems. Dates of emergence of imagoes, July 28 to August 4.

The larvae are very common and scarcely any of the young—at the time almost unbranched plants—escape. On the much-branched, bushy plants of later summer and fall, the earlier injury by the larvae is noticeable only on careful examination. Larvae are occasionally seen on the related *Sabatia*.

There is but one generation a year. It is suggested that, instead of the apparent two generations per year observed by McDunnough at Nordegg, Alberta (1927, Trans. R. S. C., p. 182), there may be two separate strains, attached to different species of gentian with somewhat different time of development.

***Adaina cinerascens* Walsingham.**

Larvae were found commonly on the underside of leaves of *Balsamorhiza sagittata*, in the sagebrush association, Logan, Utah, June 17 and 21, 1924. No description of the larva was made at the time; it is of the usual depressed form of the genus, with setae and conspicuous lateral tufts. In feeding, little patches of leaf tissue are consumed, but the upper epidermis is left untouched. Imagoes, July 2 to 8, 1924.

***Oidaematophorus confusus* n. sp.**

Dark brown, with greater or less mixture of white scales. Palpi brown, flecked with a few white scales; antennae pale luteous, with dark brown dots above; head whitish between antennae, brownish behind. Thorax anteriorly and bases of tegulae whitish; posteriorly brown, with lateral and dorsal posterior margins conspicuously margined with white, the white broadest posteriorly, where it is slightly produced forward on the mid-dorsal line. Abdomen brownish; first segment with conspicuous lateral white line; remaining segments with more or less distinct very slightly oblique lateral blackish and white stripes; in female the posterior margins of the abdominal segments are whitish, that of the first conspicuously so. Fore and middle legs white, fore tibiae with white stripes in-

wardly and a moderate tuft of brown and white scales, middle tibiae with two moderate brown tufts; hind legs brown with upper side of spurs and an annulus between spurs white; tarsal segments two-thirds or more white.

Fore wings dark brown, with a scattering of white scales, and with white scales predominating at the base of the cleft and in the lobes, which contain no defined streaks or markings, other than a small inconspicuous unmottled brown spot on inner margin of first lobe before apex, and two smaller brown spots, sometimes lacking, on inner margin of second lobe and an inconspicuous apical spot. A brown spot before base of cleft is produced about one-third toward base, and obliquely connected with a brown spot on costa above cleft. Cilia brown with an ochereous pencil opposite brown spot on inner margin of first lobe, on either side of which the cilia are much darkened; scarcely defined paler pencils opposite the brown marginal spots of second lobe. Hind wings whitish, densely but finely irrorate with grayish brown scales, in general concolorous with the fore wings, bases of cilia paler. Expanse 23-24 mm.

Type.—♂, Mills College, Alameda County, California, reared on *Baccharis pilularis*, imago emerging May 10, 1908. In author's collection.

Paratypes.—1 ♂, reared, same data; No. 3154 in Canadian National Collection, 1 ♂, June 12, 1908; 1 ♀, May 28, 1908; all from the same locality as the type.

Dr. McDunnough, to whom the reared male paratype was submitted, writes as follows: "There is nothing in our collection which would match it although I have a representation of nearly all the species listed by Lindsey in his revision. I made a slide of the genitalia in the hopes that this would help and according to the slide it must be very close to what I listed as *gratiosus* Fish in my paper on plume moths which appeared in the 'Transactions of the Royal Society.' It does not quite agree, but it would seem as if it certainly fell into this group, but I cannot consider it the same as either *gratiosus* or *mizar* as it has no dark streak in the first lobe of the primaries. I wonder if, by any chance, it could be the unknown male of *baroni* Fish. It is much better marked than Lindsey's illustration of the female, but in a general way does not seem far from it and Lindsey lists one specimen from Mills College. If not *baroni* I should imagine it must be new."

The female paratype, which is much the poorest specimen of the four, is considerably abraded and hence appears much paler than the males of the series, particularly in the second lobe and dorsal area of the fore wing; otherwise it does not differ from the type, except as noted in the description. It does not show the uniform coloration nor purplish tints described by Lindsey for *baroni*.

The larvae of the two reared males were collected along with other Microlepidoptera feeding on the same plants, and no notes were made upon the early stages.

NEW SPECIES OF PSALLUS FIEB. (HEMIPTERA, MIRIDAE).*

BY HARRY H. KNIGHT,

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Psallus amorphae n. sp.

Runs in my key to *Psallus* (Hemiptera of Conn., 1923, p. 462) to the couplet with *morrisoni* Kngt. and *parshleyi* Kngt., but differs from both in having the second antennal segment yellow except at base.

♂. Length 3.2 mm., width 1.2 mm. Head: width .67 mm., vertex .28 mm. Rostrum, length 1.12 mm., extending slightly beyond hind margins of middle coxae, black. Antennae: segment I, length .24 mm., black; II, .87 mm., yellow, black at base; III, .58 mm.; IV, .43 mm.; last two segments yellowish to dusky. Pronotum: length .476 mm., width at base .99 mm.

Color black, ostiolar peritreme and lower margin of propleura pale; antennae described above. Legs black, tips of coxae, tibiae except knees and spots at base of spines, pale. Membrane and veins uniformly fuscous, slightly paler at apex of areoles. Dorsum and sides of body clothed with rather closely appressed silvery, sericeous to scale-like pubescence.

♀. Length 3.07 mm., width 1.32 mm. Head: width .65 mm., vertex .35 mm. Antennae: segment I, length .22 mm.; II, .78 mm.; III, .56 mm.; IV, .39 mm. Pronotum: length .51 mm., width at base 1.04 mm. More robust than the male but very similar in pubescence and coloration.

Holotype: ♂ July 1, 1922, Winona County, Minnesota (H. H. Knight); author's collection.

Allotype: same data as the type.

Paratypes: a large series of both sexes taken with the types on lead plant (*Amorpha canescens*) where the species was breeding. 16 ♂ ♀ June 19, 1921, 30 ♂ ♀ July 11, 1923, 12 ♂ ♀ July 10, 1924, Red Rock, along Mississippi river, Ramsey County, Minnesota (H. H. Knight); breeding on *Amorpha fruticosa*. 2 ♂ July 20, 1920, Gray Cloud Island, Minnesota (H. H. Knight). 8 ♂ ♀ July 10, 1924, Fort Snelling, Minnesota (H. H. Knight), on *Amorpha canescens*. ♂ July 9, 1925, Ames, Iowa (H. H. Knight), on *Amorpha fruticosa*.

It is interesting to note that *Psallus amorphae* breeds on two or more species of the genus *Amorpha*, whereas, *Lopidea amorphae* Kngt. breeds only on *A. fruticosa*. The genus *Psallus* belongs in a more primitive subfamily than *Lopidea*, and this suggests that the bug may have lived on the ancestral plants of *Amorpha* long before the present day species of plants had differentiated, at least long before *Lopidea amorphae* began breeding on *A. fruticosa*.

Psallus astericola n. sp.

Runs in my key to *Psallus* (Hemip. Conn., 1923, p. 462) to the couplet with *morrisoni* Kngt. and *amorphae*, but differs from the latter in having the second antennal segment black, or in the female with apical half only pale; differs from *morrisoni* in the shorter rostrum and smaller size.

♂. Length 3.1 mm., width .82 mm. Head: width .62 mm., vertex .33 mm. Rostrum, length 1.04 mm., just attaining hind margins of middle coxae,

*—Contribution from the Department of Zoology and Entomology, Iowa State College, Ames.

black. Antennae: segment I, length .216 mm., black; II, .78 mm., black; III, .56 mm., yellowish; IV, .30 mm., dusky. Pronotum: length .50 mm., width at base 1 mm.

Color uniformly black, ventral margins of pronotum, margins of mesoepimera, ostiolar peritreme, tips of coxae, and tibiae except for spots at base of spines, pale. Membrane uniformly fuscous, veins paler at apex of areoles. Dorsum and sides of the body rather densely clothed with sericeous to scale-like, silvery pubescence, intermixed on hemelytra with simple fuscous hairs.

♀. Length 2.9 mm., width 1.25 mm. Head: width .60 mm., vertex .33 mm. Antennae: segment I, length .22 mm., black; II, .74 mm., black, apical half more or less pale; III, .56 mm., pale to dusky; IV, .39 mm., dusky. Pronotum: length .50 mm., width at base .95 mm. More robust than the male but very similar in pubescence and coloration.

Holotype: ♂ May 27, 1929, Ames, Iowa (H. H. Knight); Iowa State College collection.

Allotype: taken with the type.

Paratypes: 56 ♂ ♀, taken with the types on prairie aster (*Aster sericeus* Vent.). 34 ♂ ♀ June 2, 48 ♂ ♀ June 9, 1925, 38 ♂ ♀ June 28, 1927, 36 ♂ ♀ June 20, 1929, Ames, Iowa (H. H. Knight), all taken on the host plant, *Aster sericeus*, which is found only on undisturbed native prairie, particularly the high, dry, hilly ground.

***Psallus fuscopunctatus* n. sp.**

Distinguished by the white color with numerous small fuscous dots on dorsum and femora.

♂. Length 3.7 mm., width 1.4 mm. Head: width .71 mm., vertex .34 mm. Rostrum, length 1.49 mm., reaching upon sixth ventral segment, pale, last two segments blackish. Antennae: segment I, length .25 mm., black; II, .95 mm., pale to dusky, becoming fuscous apically; III, .60 mm., fuscous; IV, .39 mm., blackish. Pronotum: length .48 mm., width at base 1.08 mm.

Color whitish, head, calli and mesoscutum yellowish; anterior angles and disk of pronotum, scutellum except basal angles, and hemelytra, rather thickly dotted with fuscous, dots somewhat thicker and darker on corium and inner half of clavus; a pair of larger spots on disk of pronotum, one each side of middle behind the calli. Head yellowish, spot each side of vertex against dorsal margin of eye, above base of antennae, lower half of face, and gula, fuscous. Sternum, across top of coxal cleft, basal half of coxae, genital segment except tip, more or less on ventral surface of abdomen, fuscous. Femora closely and thickly dotted with fuscous; tibiae white, spines pale to brownish, with distinct black spot at base of each spine; tarsi fuscous, paler on basal half. Membrane pale to whitish, anal area fuscous, dusky within apices of areoles; veins white, opaque, cubitus infuscated. Dorsum clothed with silvery, sericeous pubescence; head, laterally on pronotal disk, and embolium, clothed with longer white pubescent hairs.

♀. Length 3.25 mm., width 1.38 mm. Head: width .69 mm., vertex .39 mm. Antennae: segment I, length .22 mm.; II, .82 mm.; III, .52 mm.; IV, .35 mm. Pronotum: length .43 mm., width at base 1.04 mm. More robust than the male but very similar in pubescence and coloration.

Holotype: ♂ August 9, 1925, Veta Pass, alt. 9000 ft., Colorado (H. H. Knight); author's collection.

Allotype: same data as the type.

Paratypes: 16 ♂ ♀, taken with the types on *Artemesia frigida* Willd., where the species was evidently breeding. ♂ Aug. 27, 1924, Estes Park; ♀ Aug. 15-22, 1924, Pingree Park, Colorado (Drake & Hottes). ♂ Aug. 27, 1920, alt. 8000 ft., Estes Park, Colorado (H. C. Severin).

***Psallus nicholi* n. sp.**

Distinguished by the dark reddish-brown to black color, with antennae, tibiae, front and middle femora, pale.

♂. Length 3.46 mm., width 1.43 mm. Head: width .65 mm., vertex .35 mm. Rostrum, length 1.5 mm., reaching upon fourth ventral segment, reddish brown, apex black. Antennae: segment I, length .26 mm., blackish; II, 1.16 mm., pale, becoming dusky apically; III, .78 mm., blackish; IV, .35 mm., blackish. Pronotum: length .61 mm., width at base 1.12 mm.

General coloration dark reddish-brown to black, pronotum more black than the hemelytra; cuneus narrowly pale at apex and fracture. Membrane uniformly black, a very distinct clear spot at apex of cuneus, its posterior margin extending from tip of smaller areole in an arcuate line to tip of cuneus; veins white, cubitus infuscated except at apex of areole. Legs pale, coxae and hind femora dark reddish brown, front and middle femora with two rows of small fuscous points on apical half of anterior face; tibial spines black, without black spots at base, tips of tarsi fuscous. Dorsum clothed with closely appressed, silvery to golden brown sericeous pubescence, much as in *ancorifer* Fieb. but the intermixed, simple black pubescence much finer. Genital structures distinctive, the right clasper much broader and larger than in *ancorifer*.

♀. Length 3.8 mm., width 1.7 mm. Head width .69 mm., vertex .41 mm. Antennae: segment I, length .26 mm., pale to dusky, black at base; II, 1.25 mm., pale; III, .82 mm., black; IV, broken. Pronotum: length .73 mm., width at base 1.25 mm. Form more robust than in the male but very similar in pubescence and coloration.

Holotype: ♂ September 26, 1925, Santa Rita Mts., Arizona (A. A. Nichol); author's collection.

Allotype: same data as the type.

Paratypes: ♀, taken with the type. ♂ September 4, 1925, type locality (A. A. Nichol).

***Psallus cercocarpicola* n. sp.**

Distinguished by the uniformly black color, pale spot on vertex, tumid frons, and silvery sericeous pubescence.

♂. Length 3.7 mm., width 1.6 mm. Head: width .93 mm., vertex .47 mm.; strongly vertical, frons distinctly tumid, facial angle slightly greater than a right angle. Rostrum, length .95 mm., reaching to middle of intermediate coxae, black. Antennae: segment I, length .26 mm.; II, .97 mm.; III, .56 mm.; IV, .34 mm.; black, last two segments more brownish black. Pronotum: length .69 mm., width at base 1.34 mm.

Color uniformly black, a transverse pale spot on base of vertex, ostiolar peritreme and ventral margin of propleura pale to dusky. Membrane dark fuscous, a paler area on middle of apical half, also a small pale spot at tip of cuneus, veins fuscous to brownish. Rather thickly clothed with white to silvery, sericeous pubescence, and intermixed with more erect, simple, black pubescent hairs.

♀. Length 4 mm., width 1.9 mm. Head: width 1.01 mm., vertex .56 mm. Rostrum, length .99 mm., just attaining hind margin of the sternum. Antennae: segment I, length .26 mm.; II, 1.07 mm.; III, .65 mm.; IV, .30 mm. Pronotum: length .76 mm., width at base 1.51 mm. More robust than the male but very similar in pubescence and coloration.

Holotype: ♂ August 7, 1925, two miles above Stonewall, alt. 8600 ft., near Trinidad, Colorado (H. H. Knight); author's collection.

Allotype: same data as the type.

Paratype: ♀, taken with the types on Mountain Mahogany (*Cercocarpus parvifolius*) which is doubtless the host plant; ♂, 2 ♀, July 22, 1928, Raton, N. Mex. (A. A. Nichol).

***Psallus carneatus* n. sp.**

Distinguished by the yellowish to carneous color, beneath more salmon, hemelytra with carmine, embolium and narrow margins of cuneus white.

♀. Length 4.3 mm., width 1.8 mm. Head: width .86 mm., vertex .47 mm. Rostrum, length 1.7 mm., attaining hind margins of posterior coxae, yellowish, apex blackish. Antennae: segment I, length .26 mm., reddish yellow; II, 1.12 mm., pale to yellowish; III, .86 mm., pale to dusky; IV, .39 mm., dusky. Pronotum: length .74 mm., width at base 1.49 mm.

Color carneous above, beneath more salmon, hemelytra with carmine; embolium and margins of cuneus white. Membrane pale, dusky brown within areoles, veins pale to reddish, white at tip of smaller areole. Legs pale to salmon yellow, femora with several setigerous fuscous dots on apical half; tibiae pale, opaque white on dorsal surface, set with black spines, each with black spot at base; tarsi pale, blackish at apex. Dorsum clothed with pale to golden yellow sericeous pubescence and rather sparsely intermixed with simple fuscous hairs.

Holotype: ♀ June 20, 1926, Fresno, California (C. J. Drake); author's collection.

Paratypes: ♀, taken with the type. ♀, California (Coquillett). ♀, Los Angeles, California.

***Psallus vaccinicola* n. sp.**

Hemelytra, carmine red, cuneus with pale crescent at base; male distinguished by a spine bearing tubercle set above base of left clasper.

♂. Length 3.3 mm., width 1.3 mm. Head: width .73 mm., vertex .33 mm. Rostrum, length 1.12 mm., reaching to middle of hind coxae, pale yellowish. Antennae: segment I, length .21 mm., pale to yellowish; II, .95 mm., pale, tinged with reddish; III, .52 mm., pale to dusky; IV, .30 mm., dusky. Pronotum: length .47 mm., width at base 1.04 mm.

Carmine red above, more orange on head and pronotum; anal ridge at tip of clavus, narrowly at apex and crescent at base of cuneus, white. Membrane pale, veins reddish, slightly dusky within areoles. Ventral surface orange red

to carmine, margins of propleura and epimera pale. Legs pale, femora with two rows of fuscous dots on anterior face, tibial spines and spots at base black, tips of tarsi fuscous. Clothed with yellowish to golden brown sericeous pubescence and intermixed with dusky simple pubescence. Genital structures distinctive, an erect tubercle bearing six or seven spines situated just above base of left clasper.

♀. Length 3.5 mm., width 1.47 mm. Head: width .71 mm., vertex .36 mm. Antennae: segment I, length .22 mm.; II, 1.04 mm.; III, .51 mm.; IV, .34 mm. Pronotum: length .56 mm., width at base 1.13 mm. Slightly more robust than the male but very similar in pubescence and coloration. Sometimes the embolium largely pale but the smaller size and large pale crescent on base of cuneus will distinguish this species from *carneatus*.

Holotype: ♂ June 22, 1925, alt. 7000 ft., Grand Canyon, Arizona (A. A. Nichol); author's collection.

Allotype: taken with the type on *Vaccinium* sp. by Mr. Nichol.

Paratypes: 2 ♀ June 2, 1925, Mission Canyon, Santa Barbara, California (Harold Morrison). ♂ ♀, San Diego, California (G. H. Field).

***Psallus rubrofemoratus* n. sp.**

Distinguished by the blood red femora, pale tibiae and dark body.

♂. Length 3.1 mm., width 1.2 mm. Head: width .67 mm., vertex .28 mm. Rostrum, length 1.08 mm., reaching to middle of hind coxae, pale; first and last segments black. Antennae: segment I, length .21 mm., pale; II, .69 mm., pale, apical half fuscous; III, .31 mm., blackish; IV, .30 mm., blackish. Pronotum: length .49 mm., width at base .99 mm.

Head, thorax and abdomen black; hemelytra dark fuscous to black, basal half of embolium and clavus largely, pale. Cuneus black, narrow apex and more broadly at base, pale; tip of embolium white. Membrane dark fuscous, veins pale. Coxae black, femora blood red, tips pale; tibiae pale, spines black, without distinct spots at base; tarsi pale, apical segment fuscous.

Holotype: ♂ July 27, 1917, Mt. Lemon, Santa Catalina Mts., Arizona (H. H. Knight); author's collection.

***Psallus atritibialis* n. sp.**

Distinguished by the small size, slender form, large eyes, black color including tibiae, and silvery sericeous pubescence.

♂. Length 2.8 mm., width 1.12 mm. Head: width .69 mm., vertex .23 mm.; eyes large, dorsal width of one just equal to that of vertex; facial angle slightly more obtuse than a right angle. Rostrum, length .73 mm., black, scarcely attaining hind margin of sternum. Antennae: segment I, length .17 mm., black; II, .84 mm., pale, ring at base and more or less shaded on apex with fuscous; III, .56 mm., black; IV, .52 mm., black. Pronotum: length .56 mm., width at base .91 mm.; prominent sericeous pubescence on anterior margin suggests the presence of a collar.

Color uniformly black, narrowly pale across base of cuneus; ostiolar peritreme pale to greenish. Membrane uniformly dark fuscous, veins paler. Legs, including tibiae and tarsi, uniformly black. Clothed with moderately thick,

silvery sericeous pubescence, simple pubescence scarcely evident.

♀. Length 3 mm., width 1.25 mm. Head: width .65 mm., vertex .30 mm. Antennae: segment I, length .17 mm., black; II, .78 mm., pale, black at base, dusky on apex; III, broken. Pronotum: length .58 mm., width at base 1.04 mm. Slightly more robust than the male but very similar in color and pubescence; anal ridge and spot along base of radius, slightly pale.

Holotype: ♂ July 12, 1925, Tucson, Arizona (A. A. Nichol), taken at light; author's collection.

Allotype: July 22, 1925, topotypic (R. B. Streets).

Paratypes: 3 ♂, taken with the holotype. ♂, taken with the allotype. 2 ♂ July 22, 1917, Tucson; 4 ♂ July 24, 1917, near Oracle, Arizona (H. H. Knight), taken at light. ♂ July 20, 1917, Texas Pass, Arizona (H. H. Knight), at light.

***Psallus flaviclavus* n. sp.**

Allied to *picicola* Kngt., but distinguished by the shorter antennae, in both sexes segment II not equal to width of head across eyes.

♂. Length 2.6 mm., width 1.17 mm. Head: width .65 mm., vertex .34 mm. Rostrum, length 1.3 mm., reaching upon seventh ventral segment, black. Antennae: segment I, length .22 mm., pale; II, .56 mm., equal to thickness of segment I but tapering to more slender at base, pale, dusky pubescent; III, .47 mm., slender, pale to dusky; IV, .34 mm., dusky. Pronotum: length .45 mm., width at base .95 mm.

Color fuscous to black, nearly as in *picicola*, but hemelytra distinctly paler and tinged with reddish; clavus chiefly pale, tinged by red in the hypodermal layer. Clothed with golden to fuscous simple pubescence and intermixed with moderately abundant, more closely appressed, silvery to golden, sericeous or scale-like pubescence; the simple pubescence not so abundant and heavy as in *picicola*.

♀. Length 2.9 mm., width 1.3 mm. Head: width .67 mm., vertex .34 mm. Antennae: segment I, length .22 mm.; II, .56 mm.; III, .47 mm.; IV, .32 mm. Slightly more robust than the male but very similar in pubescence and coloration.

Holotype: ♂ August 24, 1925, Estes Park, Colorado (H. H. Knight); author's collection.

Allotype: taken with the type.

Paratypes: 14 ♂ ♀, taken with the types on western yellow pine (*Pinus ponderosa scopulorum*). I did not take specimens on the typical *Pinus ponderosa* which has very long leaves, but only on the variety *scopulorum* which has shorter leaves.

***Psallus nigrovirgatus* n. sp.**

Distinguished by the pale and black striped color pattern; suggestive of *Phylloidea picta* Uhler but differs in the scale-like pubescence and small size.

♂. Length 2.9 mm., width 1.08 mm. Head: width .74 mm., vertex .39 mm.; short, strongly vertical, vertex on same level as dorsal margins of eyes; facial angle slightly obtuse. Rostrum, length .95 mm., reaching upon third ventral segment, pale to brownish, first and last segments blackish. Antennae:

segment I, length .15 mm., blackish, base and apex pale; II, .60 mm., pale; III, .36 mm., fuscous; IV, .28 mm., blackish. Pronotum: length .39 mm., width at base .91 mm.

Color pale and marked with black; head yellow, tylus black, vertex and lora fuscous; pronotum pale, calli, anterior margins and propleura largely yellow, basal third of disk black; scutellum black, mesoscutum orange to reddish; hemelytra pale or whitish, inner half of corium, apical third of embolium except tip, and cuneus except basal angle, dark fuscous to black. Membrane rather uniformly pale fuscous, anal area and areoles slightly darker, veins pale to dusky. Venter fuscous to blackish, sides of genital segment yellowish; sternum and pleura fuscous, episternum, ostiolar peritreme, and bases of coxae, yellow to orange. Legs pale to dusky, femora with an obsolete row of fuscous dots on median line of anterior face; tibiae pale, spines and small spot at base of each, black, ultimate tarsal segment fuscous.

Clothed with moderately abundant, white sericeous pubescence, and intermixed with more erect, simple, black pubescence.

♀. Length 2.8 mm., width 1.2 mm. Head: width .80 mm., vertex .40 mm. Antennae: segment I, length .17 mm.; II, .65 mm.; III, .35 mm.; IV, .30 mm. Pronotum: length .43 mm., width at base .97 mm. More robust than the male but very similar in pubescence and coloration; scutellum frequently more yellow than black.

Holotype: ♂ August 24, 1925, alt. 8000 ft., Estes Park, Colorado (H. H. Knight); author's collection.

Allotype: same data as the type.

Paratypes: 14 ♂ ♀, taken with the types on *Pinus ponderosa* where the species was breeding. 2 ♂ 2 ♀, August 7, 1925, Stonewall, alt. 8500 ft., near Trinidad; 9 ♂ ♀ August 20, 1925, Pingree Park, Colorado (H. H. Knight); all taken on *Pinus ponderosa*. ♂ July 23, 1907, Pine, Colorado (C. A. Hill). ♀ Aug. 16, Las Vegas, New Mexico (Barber & Schwarz).

THE CHIRPING RATES OF THE SNOWY TREE CRICKET (*OECANTHUS NIVEUS*) AS AFFECTED BY EXTERNAL CONDITIONS.

BY H. A. ALLARD,

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The common snowy tree cricket (*Oecanthus niveus*) of North America has made a prominent name for itself in American scientific literature. In fact none of our crickets have been so much discussed as this interesting pearly winged insect. There is something in its solemn, rhythmic, time-marking chirping that commands attention, so that all become impressed with its rhythmic music.

In New England, it was one of the first crickets that came into my consciousness as a child. Having a somewhat poetic temperament, its notes early affected me with their implications of poetry, a poetry born of a sweet loneliness and happy solitudes experienced on a quiet, isolated New England farm at West Oxford, Massachusetts. In August almost to a day these ominous crickets always came to tell us it was nearly fall, and I was taught to know them as the

fall or autumn crickets.

There were thousands on this farm, and there were calm and peaceful nights when even the moonlight itself seemed moved to dreamy, soothing cadences by their restless wings. I was early impressed with their synchronous concerts, concerts in which groups chirped more or less in unison, as bodies of men would swing their tread into step. Such singing resulted oftentimes in a measured beat or tread marvellously impressive to the listener and to the musing, impressionable poet.

Many personages famous in American literature and science have observed, investigated, praised the noisy concerts of this little cricket, always with a seriousness bespeaking something of an extraordinary effect in its wing-made minstrelsy. The weird genius, Thoreau of Concord, called it a "slumbrous breathing;" calmly philosophical old John Burroughs called it a "rhythmic beat;" the imaginative Hawthorne poetically heard it as "an audible stillness" which "if moonlight could be heard it would sound like that." These are the impressive words and moods of our genuinely literary men. An imposing galaxy of scientific men have also hesitated in their cosmic musings hoping to wrest definite answers from particular distinctive behaviors of its life. Among these are listed some of our most prominent entomologists of the old school, Samuel Scudder, preeminent among them. Fitch, Riley, Packard, Dolbear, C. A. and E. A. Bessey, Edes, A. F. Shull, R. E. Snodgrass, F. E. Lutz, B. B. Fulton and others with the serious mein of biologist or entomologist, have given their best scientific moods and efforts to these solemn-voiced crickets. Why has this cricket so profoundly affected biologists? Because the habit of singing in unison has been imputed to it, and because it has been regarded as a sort of handy living cosmic thermometer, supposedly delivering its chirps at definite rates depending upon the air temperatures around it.

In spite of the wide literary and scientific publicity given to the snowy tree crickets, their own moods remain the same, the annual broods coming and going with eternal song oblivious of it all, and men appear to have solved little concerning the innate moods of its subtle cricket existence.

When we consider the matter from the earliest authentic records, we find an older story than we had supposed. The first definite account of the snowy tree cricket's rate of chirping as influenced by temperature appears to have been made by Margarette W. Brooks¹ who gave a series of twelve observations of these crickets made presumably near Salem, Massachusetts, over a period extending from September 30 to October 17. In this period there was a swing of temperature from 52° F. to 73° F. She did not name the crickets, but as these were tree crickets with an intermittent note, she unquestionably had under observation the familiar snowy tree cricket (*O. niveus*). Her curiosity was aroused by a statement published in a Salem Gazette of the time and signed W. G. B. giving the following rule. "Take seventy-two as the number of strokes per minute at 60° temperature, and for every four strokes more add 1°, and for every four strokes less deduct the same." Similar statements have at various times appeared long ago in Boston papers, and they continue to appear in various newspapers each

1.—"Influence of Temperature on the Chirp of the Cricket," Popular Science Monthly XX, p. 268, November 1881 to April 1882.

autumn, having appeared in a Washington paper in 1928 in virtually the same form.

From these obscure hints probably first published in various newspapers prior to 1882, these crickets in the role of thermometer crickets passed into the records of dignified science with a vengeance, beginning with Margarette W. Brooks. Yet some one back of her had long ago sensed the role temperature played upon the rate of their chirping, and little more has been accomplished since except to pass from tabulated data to graphs, and from graphs to increasing doubts and fears in the final analysis, as to the meaning of it all. Nevertheless it is an interesting story.

In 1897 A. E. Dolbear² published his famous formula. Like Margarette W. Brooks, who must be given priority by fifteen years, Dolbear did not name his crickets, but the circumstantial evidence of the case is strong enough to made them assignable with little doubt to the snowy tree cricket (*O. niveus*). Dolbear gave the matter more of an algebraic stamp than did Margarette Brooks, with his famous formula $T = 50 + \frac{N-40}{4}$ where T = the temperature sought and N = the number of observed chirps per minute. Dolbear was the first observer to publish in scientific annals a statement that the crickets chirped in unison, and he did it in a rather wholesale, dogmatic way that has awakened the interest of of biologists as to the actualities of the behavior. He said: "An individual cricket chirps with no great regularity especially in the daytime. At night when great numbers are chirping the regularity is astonishing, for one may hear all the crickets in a field chirping synchronously, keeping time as if led by the wand of a conductor." This broad, dogmatic statement could not long go unchallenged and we shall see that it is responsible for much of the subsequent interest biologists have shown in these crickets.

A year later, C. A. and E. A. Bessy³ published on these crickets, making their observations at Lincoln, Nebraska. They studied the matter in detail statistically, and finally recommended the formula $T = 60 + \frac{N-92}{4.7}$ where T = the temperature required, and N = the number of chirps per minute observed. They concluded that the matter was not as simple as Dolbear thought, and that something changed the constant when temperatures fell below 60°, so that expectations from the above formula were not quite accurate. In other words while the equation *might* be accurate to within 1 or 2 degrees between 60° and 80°, below 60°, computations gave results too low. They concluded that a gentle curve, rather than a straight line expressed more accurately the truth of the relation between the rate of chirping and the air temperature affecting the crickets. This was the first contribution of scientific standing indicating that the matter was not as simple, as direct, as invariable as it had been considered. The Bessys were the first to see that the crickets under observations were the famous snowy tree crickets, by actual identification.

In 1899 Robert T. Edes⁴ published his observations. Edes mentions a note which appeared in the *Boston Transcript* calling attention to the exact depend-

2.—"The Cricket as a Thermometer," *The American Naturalist*, XXXI, 970-971, 1897.

3.—"Further Notes on Thermometer Crickets," *The American Naturalist*, XXXII, 263-264, 1898.

4.—"Relation of the Chirping of the Tree Cricket (*Oecanthus niveus*) to temperature," *The American Naturalist*, XXXIII, 1899, 935-938.

ence of the rapidity of chirping upon the air temperatures experienced by the crickets. Edes questioned the matter of synchronized chirping as observed by Dolbear (1897), and is inclined to regard it as more or less of an illusion.

In 1907 A. F. Shull⁵ published a lengthy paper on various aspects of the chirping of the snowy tree crickets in relation to external and internal factors.

Shull took up the question with great enthusiasm, and with a determination to reduce the matter to its final terms of truth. His intensive studies of these crickets at Ann Arbor, Michigan, at New Carlisle, Ohio, and at Ithaca, New York, revealed new relations which previous workers had overlooked. When he had finished with the problems, for the first time, these crickets as accurate out-of-doors clocks began to lose their cosmic status.

Shull, as have all who have studied the problem, found a general correspondence between the rates of chirping of these crickets and the temperatures they expressed, but he concluded that there were certain variables present which could not be reconciled directly with observed air temperature readings. In other words as he expressed it the rate of chirping did not follow any law based upon temperature. He even found in certain cases that the same crickets forgot somehow their temperature restrictions, so that a higher rate at times accompanied the lower temperature. He found errors as large as 6° to 9° from calculations using the Dolbear and the Bessy formulae. Wing-length proved to have no relation to the rate of chirp, as indeed it should not according to the laws of life, for no population of crickets or any other creatures is of one size, one degree of strength, vitality, energy, impulse, or proportion.

Shull was inclined to believe that the variations from the temperature rule were dependent upon humidity. In one instance he found that a few crickets chirping at a height of 12 feet above the ground, decreased their rate much more rapidly than those near the ground level. He was inclined to consider the changes as due to an increasing humidity, for neither of the simple temperature formulae of Dolbear or the Bessys accounted for the marked reduction.

However, Shull mentions that a light wind was stirring. This would perhaps affect the evaporative rates, which in turn might chill or benumb the crickets without noticeable changes in air temperature as recorded by a thermometer in the air currents. We turn on our fans not to change the air temperatures, for the air is no cooler, but to increase the evaporative capacity of the air as it passes over our skins, and we feel it as coolness with a comfortable or uncomfortable reaction. It is possible that with mist or moisture on their bodies, a slight motion of the air would produce sensations of profound physiological coolness. Since they are essentially cold blooded creatures, this chilling may induce marked physiological reactions independently of the observed air temperatures.

Shull considered the matter of the so-called chirping in unison in some detail, but felt that it was a relationship not between many crickets in a field, but between only two or three near neighbors, if there were any synchronism at all. Strangely enough, Shull evinces a mood of doubt in his calm discussion of this behavior, and his evidence based upon a particular case of two individuals is more in favor of such a behavior than against it, it seems to me. So closely did these

5.—"The Stridulation of the Snowy Tree Cricket (*Oecanthus niveus*). *Canadian Entomologist*, XXXIX, 1907, 213-225.

chirp in unison that for some time he did not realize that more than one cricket was chirping. He says. "One evening I discovered two crickets about five feet apart chirping in such accurate unison that I did not at once realize that there were two crickets. One soon stopped; the second hesitated, its chirps became weak, and it even lost a beat. After an irregular solo of several minutes, the second cricket recommenced. At the first chirp the first cricket struck a note out of time, then lost a beat, as if startled. It next voiced a half dozen weak, uncertain chirps, then the call gradually grew in intensity, until the two crickets were again chirping in exact unison." This observation it seems to me would imply that the crickets not only heard their own sounds, but that they were attempting to preserve a unison in their chirping. Shull says in this connection: "It seems from my observation that synchronism may possibly be due rather to the effect of each cricket's chirp upon the other cricket."

Shull noted marked individual variations in the chirpings of certain populations of crickets, and he considered the possibility of physiological state as an internal factor, such as hunger, sexual moods and age.

In 1917 and 1918 I⁶ published observations bearing on the matter of synchronous chirping in the behavior of crickets and other creatures, in which the stand was taken that the snowy tree crickets (*Oecanthus niveus*) have the habit of chirping in unison, while other crickets with the intermittent chirping habit never give this impression.

In 1925 B. B. Fulton⁷ published an interesting paper on the snowy tree crickets.

Fulton found marked racial differences in the rates of stridulation of these crickets from Oregon, Arizona and Ohio, and he concludes "that this variation is not dependent on the local physical conditions of the environment." He analyzed the quaver in the note and found that the wings of some chirping individuals made four strokes and in others only three to produce each separate, intermittent chirp. He studied the matter of synchronism and is convinced that under certain conditions these crickets will sing in unison. From studies of crickets indoors under controlled conditions he says: "when one male is singing and another begins the second one will make a few notes until it can catch the proper rhythm and then its notes sound simultaneously with the other." From a few observations he was inclined to believe that humidity under the conditions of their chirping, did not play much part on the rates of delivery.

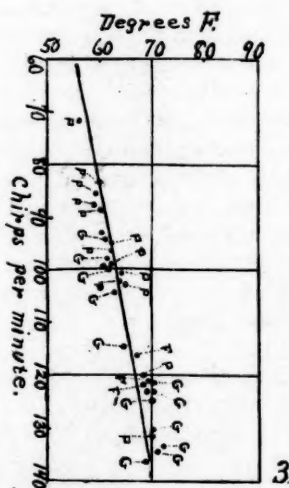
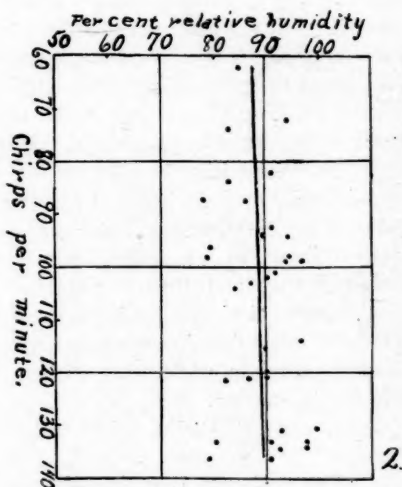
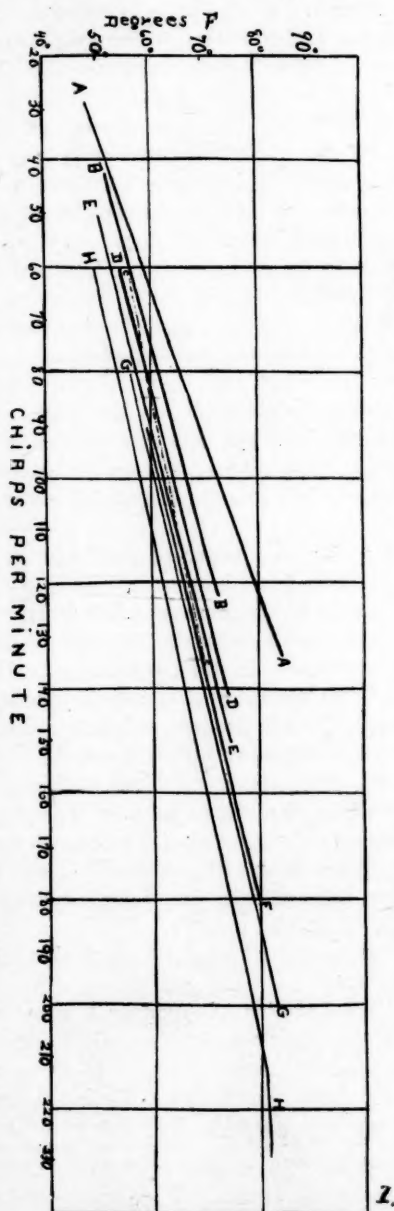
In 1928, Fulton⁸ published two additional papers involving considerations of the snowy tree crickets.

In his paper "A Demonstration of the Location of Auditory Organs in Certain Orthoptera," he sets forth the results of important experiments with these crickets, to show that they hear with the typanal structures situated on their fore tibiae, basing his conclusion upon the same old troublesome question of their ability to chirp in unison. A group of control crickets were found to chirp in unison, "as

6.—"Synchronism and Synchronic Rhythm in the Behavior of Certain Creatures," *The American Naturalist*, LI, 1917, 438-446.

"Rhythmic Synchronism in the Chirping of Certain Crickets and Locusts." *The American Naturalist*, LII, 1918, 548-552.

7.—"Physiological Variation in the Snowy Tree Cricket, (*Oecanthus niveus* De Geer.)" *Annals of the Entomological Society of America* XVIII, No. 3, 1925, 363-383.



if a single cricket were singing." Another group of the same type was treated by having the fore legs possessing the tibial auditory organs amputated. These now chirped observing no rhythmic unison whatever, but produced "an utter confusion of notes."

In 1927, I made further observations of the chirpings of the snowy tree crickets at Clarendon, Virginia, over a period extending from August 13 to September 7. A stop watch timing to $1/5$ of a second, a standard Fahrenheit thermometer and a sling psychrometer were used to determine accurately, temperature and humidity relations obtaining out-of-doors near the bushes in which the crickets were chirping. Half a dozen or more were chirping in the shrubby clumps of a small area scarcely more than six feet above the ground, so that conditions were fairly convenient for moving among them and determining environmental conditions. These crickets remained practically stationary in their locality throughout the period as is the usual habit.

In the determination of the data, two methods of counting were observed to get the rate of chirping per minute. In one set, an actual count for a minute of time was made, this being repeated, from two to five times, at close intervals. A second method involved the count of one hundred chirps and the time elapsed to fifths of a second. This was also done from 2 to five or six times. Calculations were then made from this data, to determine the rate per minute. In a sense, these two methods acted as controls upon each other, and at the same time gave for each reading a set of five to ten different figures, which were used for a single mean value. These mean values were used in the data of least squares for the determination of the graphs. It is surprising how closely these two methods of counting for the rates of chirping per minute agreed, as they naturally should with accurate counts per unit of time.

A straight line graph was made based upon the theory of least squares, for the observed rates of chirping and the air temperatures found and likewise for the relative humidity. The temperature graph is included with those of Margarette W. Brooks, Edes, Faxon, the Besseys, and Fulton, and is represented by the broken line among these. It is evident that the same general increasing trend with higher temperature is shown in the rate of stridulation as observed by others.

This was to be expected for this general trend unquestionably exists. Of course individual behaviors show wide departures from average values, but this is a purely normal expression of the populations of life, whatever the organism considered.

As did Shull I have also found disturbing, erratic departures from an expected constancy that are not readily accounted for by air temperature determinations or other obvious external factors affecting the activities of the crickets. In agreement with his data I have also found the higher rate sometimes associated with the lower temperature. At a temperature of 70° , the extremes have ranged from 121.7 chirps per minute on the evening of August 23, to 133.7 chirps per minute on the evening of August 22. At the lower limits of temperature, tempera-

8.—"Sound Perception by Insects," *Scientific Monthly*, XXVII, 1928, 552-556.

"A Demonstration of the Location of Auditory Organs in Certain Orthoptera," *Annals of the Entomological Society of America*, XXI, 1928, 445-448.

tures of 56° and 56.5° F. consistently gave rates of 71 and 62.2 chirps per minute respectively.

Humidity determinations with the sling psychrometer considered in connection with the rates of chirping, show almost no correlations as the graph and individual records indicate.

At the time the observations were made, careful attention was given to the matter of synchronism or singing in unison, and the occurrence or absence of this behavior was noted in most instances. There was evidence of marked variations in this behavior, yet the highest temperature for some reason seemed to be correlated generally with the most evident synchronism, although this was not an invariable rule.

From the previous discussion, it is evident that our little snowy tree crickets have never ceased to be of interest to the laity and the scientific world. This interest has hinged around two rather striking behaviors imputed to this cricket, singing in unison, or keeping time, and varying its rate of chirping with the air temperatures affecting the insect. That there is a general and fairly close correlation between the rate of chirping and the temperature of the air is too evident to be denied. However, the matter is more complex than Margarette W. Brooks, Dolbear and others have indicated. Shull was the first to bring doubt into the matter, and one must admit that these doubts are founded on fact, whether or not we know all the reasons behind them all. The crickets may at times be good cosmic clocks, but the main spring of their running is subject to unpredictable tightenings and loosenings in a rather irresponsible way. Whether all this is due to a cold, impersonal determinism dependent upon external factors is not clear, but unquestionably internal *physiological states* as considered by Shull must play a part. A cricket is a plastic living entity, regardless of its physico-chemical processes. It is therefore subject to the normal fatigues of life, for no organism is independent of physiological fatigues and indifferent moods, incident to the influences of hunger, of sex, activities, of work, of age, of permanent or varying conditions of individual comforts, health and vigor.

I am ready to throw additional doubt into the matter as did Shull in his time, for I am now inclined to believe that we know relatively little in a quantitative way of the critical external conditions which may affect the chirping rates of these crickets.

It is well known that the snowy tree crickets chirp mainly from dusk into the night. They are chiefly nocturnal in this behavior, and if they are noisy at all in the daytime, during the height of their season, it is during heavy cloudy weather.

The question now arises; what factors lead it to stridulate at night normally? Is it light, temperature, humidity? One may at first sight say light, but with the evening oncoming, air temperatures fall usually below 70° F., much lower than the average temperature of the sunnier hours of a mid August day. At the same time this is accompanied by a rapid rise in humidity, usually above 70° , ranging from 74° to 100° in the Washington region, depending upon the locality, the height of the crickets above the ground, the temperature of the air currents and strata, wind movements, etc. So the matter of the day and nighttime activities

of the crickets is not as clear as it may at first appear. On cloudy days the temperatures are lower, the light intensity values are lower, and the humidity relations are likely higher than on sunny days, but all these conditions tend to approach the conditions of the evening and nighttime, to which the crickets are exposed when active chirping is their habit.

It would seem that we have much to learn concerning the responses of these crickets to daytime conditions. My own humidity data refer alone to conditions of relative humidity above 74 within the range of the normal night humidities. What would be the chirping rates in response to relative humidities below 74? Practically all the night temperatures during the chirping season range between 50° and 70°F. How would high temperatures ranging from 70° to 95° or 100°, the normal conditions of the daytime affect the activities of these crickets? What would these ranges bring about in conditions of weak light or in darkness? I must confess I am no longer certain of anything actually responsible for the impressive chirping relations of these crickets.

I wish, however, to bring to the attention of biologists interested in the relations of the chirping activities of snowy tree crickets to temperature, a factor which it seems to me has been consistently ignored, yet it is one which may perhaps profoundly affect their chirping rates, depressing it below observed values of the air temperature and formulae derived from them. I refer to the evaporative cooling effect of the air flowing over their bodies. While studying the rhythmic chirpings of these crickets I have noticed that slight changes of air movement, as light breezes may affect their rates of chirping momentarily, and they often-times appear somewhat disconcerted under such conditions. There is no reason why the body of a cold-blooded cricket should not be chilled or even benumbed by the evaporative capacities of the varying air currents blowing upon it. It is well known that a current of air, other conditions being equal, cools by enhancing evaporation from the skin. That is why we find comfort in sitting before our fans on hot, oppressive days. The air which is rarely saturated cools our skins by evaporation, fresh air of the same evaporative capacity being eternally renewed as the air current comes and goes.

I am inclined to believe that this is the factor which most affected the crickets observed by Shull at different heights above the ground, where the higher crickets reduced their chirping rates most noticeably.

In a consideration of the temperature factor itself as affecting the rates of chirping one must, then, think of it in all its phases, the one being the direct effect of the air temperature upon its body, the other an indirect effect due to cooling by evaporation. The latter is a function of the temperature, the degree of relative humidity and the velocity of the wind. While air temperatures are easily determined, the matter of determining accurately the evaporative capacity of the air, and its specific cooling effects upon the body activities and expressions of the crickets is not so evident.

With respect to the matter of chirping in unison, the observer can merely record his impressions. I have no doubt, whatever, concerning such a behavior by these crickets under certain favorable conditions. However, I do not feel that all the crickets in a field or an extensive thicket can strike their notes in unison as

if led by the wand of a conductor as Dolbear expressed it. This may have been Dolbear's honest impression, but the matter must inadvertently have been somewhat overdrawn. I myself have been inclined to note such effects, but the facts at hand must militate against such a universal synchronism. This would demand a single constant rate of chirping for every individual, a zone of constant air temperature over the entire area in which the crickets were distributed, a constant humidity, wind velocity and physiological level, a condition of uniformities which cannot be expected to obtain under normal, out-of-door conditions.

However, the matter of synchronized chirping does not depend upon a keeping step for every individual in a group of crickets. If only two or three crickets near one another give evidence of adjustments in order to chirp as one cricket, as Shull observed, the case is definitely proven.

The matter of chirping in unison in a small group of crickets, must admit an element of chance in the possible arrangements. In every cricket population, as Shull and Fulton have proven, individuality is a normal expectancy. Obviously two crickets chirping at a certain temperature level, let us say 65° , one at a rate of 115 notes per minute, and another at 100, cannot bring themselves into any nice time attunements upon which synchronism must always depend. In building up a small group the laws of chance, however, would allow either complete individual variability, complete individual likeness, and between these all the intermediate values. Furthermore even crickets with dissimilar inherent individual rates may even be brought into the proper rate adjustments at times by the fortuitous circumstances of the proper temperature relations. Wallace Craig⁹ is inclined to look upon synchronous chirping as a somewhat doubtful behavior, and F. E. Lutz¹⁰ questions it all asking "What would the crickets gain at any rate by chirping in unison?" (p357).

It may be said, however, that keeping step, so to speak, or arranging movements or expressions in perfect unison, or in such a diametrically opposite manner as to bring about the same orderly rhythmic relations by keeping exactly out-of-step, or singing, chirping or behaving with alternating or responsive regularity, is a behavior not by any means peculiar to men alone. This I hope to show in a future paper.

If creatures, either, crickets, birds, or men at times choose to sing, walk or play with synchronized exactness, this can only be considered an inherent property of life. I would as soon ask why these creatures exist or behave at all. We cannot ask ultimate questions of Nature or life and expect an answer. I do not yet know why the universe is here, or life, or crickets or men. They simply are; and many of their behaviors simply are. There may be moods of satisfaction and necessity in chirping, in chirping in unison, in the mere living moods of life, but no biologist can expect always to find a direct answer to the question why. I am content to learn if chirping plays any part in the life of a cricket, either esthetic or practical. I am content to learn if synchronized chirping is an indubitable fact where certain conditions are favorable for the expression. These must eternally prove very difficult questions, but life is a cosmic mystery, and its inexorable de-

9.—"Synchronism in the Rhythmic Activities of Animals. *Science*, N. S. XLIV, 1916, 784-786.
10.—"Insect Sounds." *Bulletin of the American Museum of Natural History*, L Art. VI, 1924, 333-372.

terminisms and free-will vitalisms are even more mysterious. One and all we are merely seeking Truth, in so far as our relativities of body and mind make it *Truth* for us. We cannot complain, because we can do no more. To be patient, painstaking, philosophical and tolerant should be the mood of every sincere man of science.

There is one more consideration bearing on the seasonal relations of the snowy tree crickets and other insects, which is of interest. It is the matter of longevity and the actual conditions bringing about death in the various regions throughout their range. It is not definitely known, in the case of the snowy tree crickets, what part the internal physiological complex and the external environmental factors definitely play in determining their death. However, I have observed in some detail the coming and going of various species of musical insects ranging from Washington to New England, including the snowy tree crickets.

In New England the first appearing adults are not heard until toward the middle of August. In the Washington climate, they are heard in July several weeks earlier. Strangely enough the latest snowy tree crickets surviving and singing in my garden are usually not heard after October first. Long before this time the great dreaming colonies have mysteriously, quietly passed away, leaving their favorite trees and thickets in my garden strangely silent and sad with a sense of loneliness where once the finest rhythmic music of nature reigned night after night. It is evident that frost had no part in killing these crickets, for their ranks are sadly reduced, oftentimes long before the first frosts of autumn arrive. A natural inevitable old age seems to have overtaken these little crickets so that they fell from the boughs and herbage like normally ripened fruit. The story is somewhat different in New England. They come later in the summer and may often be heard in the hey day of their singing well into October, extending their moods and modes of life into the hazards of perilous frost periods. Here they seem often to be killed almost in youth by severe frosts, for each cold spell and frosty night plays havoc with their noisy ranks. In other words the New England or northern crickets are likely to die before their physiological span of life is run, and may come to a premature and violent fortuitous death from frost by thousands like such frost-sensitive plants as sweet potatoes and tomatoes. Far southward, senility and death appear to come more from natural internal, physiological causes. The crickets are more likely to die from old age, gradually running down to a final cessation of life and activities like a wound up clock.

I have noted this seasonal relation to the normal span of life in the case of many other New England crickets and katydids having a far southern distribution. Of course the question may involve matters of unfavorable high temperatures as well in more southern latitudes, but little or nothing is known concerning the optimum conditions of existence for any of these insects.

From the previous discussion it is evident that we have a problem of no small complexity before us when we attempt to make a certain and intelligent understanding of a cricket's life and musical expression in relation to its environmental conditions. In spite of the interest and amount of attention given to the

problem it is obvious that we have as yet merely passed from feelings of an earlier cock-sure certainty to multiple doubts and uncertainties. No longer are the crickets to be considered very reliable cosmic thermometers, but endowed with a mysterious living mechanism we cannot fathom. To the uninitiated layman scarcely acquainted with all the complexities of such an organic constitution must they remain thermometers of the most complicated and variable sort in many respects. With his vaunted astuteness not even the scientist has yet been able to evaluate them and to calibrate them to any convenient standard of accuracy, for this demands a calibration based upon the individuality of the cricket, the racial behavior, and many obscure environmental conditions not yet clearly recognized and stated in mathematical terms.

EXPLANATION OF PLATE

- Fig. 1.—Graphs as found by different observers showing the general relations existing between the rates of chirping of the snowy tree cricket *Oecanthus niveus*, and air temperature from the earliest scientific record in 1882 to the present time. A—Oregon race, B—Fulton 1925, B—Margarette W. Brooks, New England, 1882, C—Allard, Washington, D. C. 1928 (Records from Aug. 13 to Sept. 7), D—Faxon, New England, 1899, E—Edes, New England, 1899, F—Fulton, Iowa, 1925, G—Bessey, C. A., and E. A., Nebraska, 1898, H—Fulton, Oregon race A, 1925.
- Fig. 2.—Graph devised by the method of least squares showing the slight relationship between the rates of chirping and the observed relative humidities from Aug. 13 to Sept. 7, 1928.
- Fig. 3.—Graph and observed rates of chirping with temperature data, and the degree of synchronism observed. At the higher rates and temperatures, chirping in unison appears to be favored. P=poor; F=fair; G=good.

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